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W. F. Graham
L. L. Hourani
D. Sorenson
H. Yuan

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NAVAL HEALTH RESEARCH CENTER
P O BOX 85122
SAN DIEGO, CA 92186-5122

BUREAU OF MEDICINE AND SURGERY (MED-02)
2300 E ST. NW
WASHINGTON, DC 20372-5300

Demographic Differences in Body Composition of Navy and Marine Corps Personnel: Findings from the Perception of Wellness and Readiness Assessment

Wendy F. Graham, Ph.D., Laurel L. Hourani, Ph.D., M.P.H., Diane Sorenson, M.P.H. and Huixing Yuan, Ph.D.

Naval Health Research Center

Health Sciences and Epidemiology Department

P.O. Box 85122

San Diego, CA 92186-5122

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Abstract

With the recent increase in women's representation in the military, baseline physical measurement data are needed to help set appropriate accession and retention standards and to design useful prevention and intervention programs in the areas of physical fitness and health. This study incorporated several body composition indices to obtain anthropometric data for a representative sample of 1292 active-duty Navy and Marine Corps women and men. It also assessed the extent to which personnel met weight-for-height and body fat standards. The prevalence of overweight was considerably lower among Marine Corps women as compared with Navy women and slightly less for Marine Corps men compared with their Navy counterparts. Between one-fifth and one-third of military personnel exceeded Navy/Marine Corps weight-for-height standards. Navy women tended to meet weight standards more often than Navy men. Fewer Marine Corps women than men were overweight but more exceeded their weight-for-height standards.

All branches of the US military employ weight or body composition standards to screen members into military service as well as to determine their fitness for continued duty.[1] With the recent increase in women's representation in the military, physical measurement baseline data for military women is needed to help set appropriate accession and retention standards and to design useful prevention and intervention programs in the areas of physical fitness and health.[2-3] Body fat standards vary between services, and, in some services, by age; however the services are consistent in recognizing a gender-appropriate level of body fat that is higher in women.[4]

In the naval services, body fat is assessed at the time of Physical Readiness Training (PRT) testing. A failed semiannual PRT screen based on a height/weight table may trigger a follow-up body fat assessment based on circumferences.[5] At the time of this study, the allowable body fat maximum for male sailors of all ages was 22%, while the maximum acceptable body fat value for women was 30%. The U.S. Marine Corps (USMC) employed a height/weight standard that was slightly more stringent than the corresponding Navy height/weight table with no body fat standard specified.[6]

There is considerable debate on the appropriateness of various weight standards for men and women of different ages and racial groups.[7] Quantification of body fat has relied on various technologies, such as hydrostatic weighing, anthropometry, and electrical impedance. Whereas hydrostatic weighing generally produces a valid and reliable result and is the current "gold standard" against which other methods are compared, it is cumbersome, expensive, and can only be accomplished in a laboratory.[8] Although anthropometry and electrical impedance lend themselves to epidemiological investigation, each of these methods presents unique problems, especially when applied to women.[8-10] The pattern of distribution of body fat is dissimilar for men and women. "Women carry more fat on and less in their smaller frames compared to men,"

[11] and they also distribute more of it to the extremities than men; this is reflected in the higher triceps and skinfold thicknesses relative to trunk measures, such as the subscapular skinfold.[8] Unlike men, women have fat deposits in the breasts, hips, and thighs to accommodate pregnancy and lactation. These gender differences have given rise to a variety of anthropometric equations that encompass various combinations of height, weight, circumference, and skinfold measurements to predict body fat. Since it is recognized that an increasing amount of body fat is associated with age, age has been added to some equations in determining body fat composition.[12] Although others argue that BF should not, ideally, increase with age, the increase is generally attributed to decreased activity.[13] This is also why there is no change in BF standards with age for the Navy.

Large national health surveys such as NHANES and the National Health Interview Survey (NHIS) have utilized body mass index (BMI) as an overall indicator of obesity. Although BMI provides only an approximation of body fat, it is a simple and convenient measure (based upon height and weight) and has been shown to be associated with disease risk.[14] The use of the BMI as an overall indicator of overweight has been endorsed by the National Institutes of Health Consensus Development Panel.[14]

The present study incorporates several of the above body composition indices to obtain baseline anthropometric data for a representative sample of Navy and Marine Corps personnel. As with the national surveys, the purpose of the present study is to help establish the normative distributions for height, weight, subscapular and triceps skinfolds, and body mass. The first specific objective of this study was to determine normative distributions of selected physical measurements and make comparisons between women and men, white versus other races, different age groups, enlisted personnel versus officers, and sailors versus marines. The second

objective was to assess the extent to which military women and men meet standards based on Navy/Marine Corps weight-for-height standards and Navy percent body fat (%BF) maximums.

METHODS

The data from this study are from a large-scale military population-based health survey entitled the 1995 Defense Women's Health Research Program Perceptions of Wellness and Readiness (POWR) Assessment. The POWR Assessment consisted of three components: a comprehensive health questionnaire to which approximately 10,000 active-duty military personnel responded, a clinically-based psychiatric telephone interview conducted with a subset of about 780 respondents, and a body measurement study of a subsample of 1292 persons on which the present report is focused.

Sample

The sample design for the POWR Assessment was a two-stage probability sample, with naval installations clustered and randomly selected at the first stage and personnel assigned to selected installations chosen randomly from within strata at the second stage. Both first and second stage samples were constructed from Navy and Marine Corps master personnel files. Stratification by service, sex, race, paygrade (as proxy for age and socioeconomic status) and geographic location was used to oversample important demographic and organizational groups with low frequency in the population, such as black female officers. The total targeted sample size for the survey consisted of 25,863 Navy and Marine Corps personnel selected from 45 geographic locations worldwide.

Since it was not feasible to measure all survey respondents, a third sampling stage was initiated at installations in which the questionnaire was administered in group sessions. These installations were determined after the original sample had been selected and included one naval

base outside the continental United States (OCONUS), two West Coast naval bases, and two West Coast Marine Corps bases. A sample large enough to yield body measurements for 800 Navy and 400 Marine Corps personnel with approximately equal representation of women and men was randomly selected (an approximate 50% subsample of the anticipated questionnaire respondent sample). Persons reporting to the group sessions were selected to participate in the body measurement study based upon predetermined demographic quotas. Target cell sizes for demographic groups were calculated based on equal numbers of men and women and were proportional to those in the original sample. As each participant signed in for the survey session, his/her demographic composition was determined from a master list and screened for meeting target cell criteria by gender, race (white vs. other), and rank (E1 to E6, E7 to E9, officer). If needed to complete the cell quota, participants were handed a study information card that indicated they had been chosen to participate in the body measurements portion of POWR '95. This procedure helped maintain the schedule of participants for measurement, avoided long wait times, and allowed for a variable number of respondents per session.

Physical measurements

Body measurements were limited to noninvasive, standardized procedures. These measurements included height, weight, neck, waist, and hip circumference; triceps skinfold; and subscapular skinfold. All equipment was prepared and calibrated in accordance with standardized protocols. This equipment included 2 digital scales, 2 calipers, and 6 tape measures.

Two Seca, model 77000, compact digital physician scales were used for weighing and calibrated at the beginning of each session. Participants were asked to remove their shoes and empty their pockets prior to stepping on the scale. Once on the scale, they were asked to look straight ahead and their weight was recorded to the nearest 0.1 kg.

Height was measured using a W.H. Collins, Inc., (San Diego, CA), plastic-coated tape measure attached to the wall. Participants were asked to stand with heels together next to the wall while a clipboard was placed on the highest point of the head and a recording was taken. The reading was verified and recorded to the nearest 0.1 cm.

Circumferences of the neck, abdomen, and hip in women were taken using a Scoville-Dritz, (Seattle, WA), plastic-coated tape measure. Participants were asked to remove their shirts for the neck and abdomen measures. If necessary, pants or skirts were lowered to gain access to the waist. In women, the hips were measured over the clothing, pulling the tape tight. These measurements were recorded to the nearest centimeter. Each circumference measurement was taken twice by the same surveyor. These measurements then were averaged. The protocol followed was from "Technique for Measuring Body Circumferences and Skinfold Thickness."[15]

Skinfold thicknesses were measured using Harpenden, John Bull calipers from Novel Products, Inc., (Holland, MI). The protocol followed was also from Beckett and Hodgdon.[15] Calipers were checked after each measurement to be sure that the indicator had returned to zero.

Construction of Body Composition Indices

Indices were constructed and cutoff values established to reflect the relative body fat of Navy and Marine Corps personnel. Among the measures used in this study were: (1) BMI; (2) %BF estimated from generalized equations using circumference measurements and height;[16,17] (3) %BF estimated by circumferences, age, and height; (4) an indication of overweight determined by gender-specific cutoff values for BMI; (5) percent exceeding the Navy's and Marine Corps' gender-based weight-for-height standards; and (6) exceeding the Navy's body fat standard, also based on gender-specific cutoff values.

The formulae for the body composition measures and cutoff values were as follows:

1. Body mass index (BMI)

   $BMI = weight\ (kg)/height\ (meter)^2$

2. Percent body fat (%BF)[a]

   $\%BF\ (women) = (161.27327 * lg_{10}\ [waist\ (in) + hip\ (in)])$

   $-(100.81032 * lg10\ [height\ (in)]) - 69.55016$

   $\%BF\ (men) = (85.20969 * lg_{10}\ [waist\ (in) - neck\ (in)])$

   $-(69.73016 * lg_{10}\ [height\ (in)]) + 37.26673$

3. Percent body fat (age-adjusted)[b]

   $BD^b\ (women) = (1.168297 - 0.002824 * waist\ (cm) + 0.0000122098 * waist^2)$

   $-(0.000733128 * hip\ (cm)) + (0.000510477 * height\ (cm))$

   $-(0.000216161 * age)$

$\%BF\ (women) = (4.95/BD - 4.5) * 100$

4. Overweight [as defined by NHANES][19]

   $Overweight\ (women) = BMI > 27.3\ kg/m^2$

   $Overweight\ (men) = BMI > 27.8\ kg/m^2$

5. Exceed Navy/Marine Corps weight-for-height standard

6. Exceed body fat standard[c]

   Navy

   Exceed body fat standard (women): $\%BF > 30.0$

   Exceed body fat standard (men): $\%BF > 22.0$

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[a] Personal communication, M.B. Beckett, August 1996.

[b] Body density (BD) was calculated and converted to percent body fat using the Siri equation.[18]

[c] The Navy uses a height/weight table for prescreening. Those who fail the prescreen are subsequently assessed for body fat.

Data collection procedures

Personnel consisting of both trained military Hospital Corpsmen and civilian contractors took measurements. Surveyors consisted of two 4-person teams, one for men and one for women, and an additional surveyor for relief or backup to fill in for any other team member during a session. An experienced anthropometrist trained the measurement teams. Measurement teams practiced and retrained until all members tested within 1 cm for circumferences and achieved a 90% interrater reliability for the skinfold measurements. Pilot testing of the physical measurement protocols was conducted on 14 volunteers from a floating dry dock and on 20 from a branch medical clinic. The measurement teams subsequently achieved interrater reliabilities between .95 and .99 for the various measurements. (Blood pressure, heart rate and handgrip strength were also measured and are subjects of a separate report). Team members worked as partners taking and recording circumference and caliper measurements. A standardized protocol for the measurement of physical parameters was developed based on a combination of the standardized NHANES and Navy anthropometric protocols.[15,20-21] Wellness newsletters and participation certificates were distributed to all participants in the physical measurement survey.

Statistical Approach

The body measurement sample data were weighted to adjust for the oversampling of women, minorities, and higher paygrades required in the POWR survey design. These poststratification weights were applied to reflect the population at the 5 sites and were computed on the basis of the relative frequency with which persons in the body measurement sample occurred in 30 classes defined by branch of service, location (CONUS vs. OCONUS), paygrade, gender, and race. Race was not used in defining the classes for female E7s to E9s or female

officers in either service because of the small respondent sample sizes. Further details on the sampling and weighting procedures are available elsewhere.[22]

Statistical analyses were conducted with the software for Survey Data Analysis (SUDAAN), a program developed by Research Triangle Institute, Research Triangle Park, NC, for the specific purpose of analyzing data from complex surveys.[23] SUDAAN permits statistical analyses of weighted data by providing correct variance estimates for multi-stage sample designs. Chi-square, t-test, and analysis of variance (ANOVA) procedures available in SUDAAN's CROSSTAB, DESCRIPT, and REGRESS, respectively, provided descriptive univariate and bivariate analyses. The t-test procedure assessed mean differences between two subgroups (e.g., men compared to women, white compared to other races) for the military population as a whole and for branch of service comparisons. Analysis of variance procedures using REGRESS assessed multiple group differences of means for age groups and paygrade. Chi-square analyses tested for significant proportional differences between the demographic subgroups and among populations of interest in the study. All p-values were two-tailed.

RESULTS

Sample Representativeness

Table 1 presents the response data and response rates for the questionnaire study and for the body measurement study. As shown, cooperation rates were very high for both Marine Corps (97.3%) and Navy personnel (89.1%). The overall response rates were lower, however, because they take into account the numbers who attended the group sessions. The final participation rates were 42.4% for the Marine Corps, 58.8% for the Navy, and 52.5% for the total sample. These rates were higher than those for the questionnaire study overall (mailed and group session).

Comparing sample demographic distributions to population distributions, the Navy and Marine Corps samples closely approximated the population values for gender and race. Officers in both branches of service were slightly underrepresented in the physical measurements sample. Offsetting this shortage of officers, the Navy sample had more E7s to E9s while the Marine Corps sample had more E1s to E6s. Self-reports of height and weight from the questionnaire data were also compared with measured height and weight from the body measurement study. Men were measured at 180.4 pounds, 70.4 inches in height, and a computed BMI of 25.6, compared with their self-reports of 178.5 pounds, 69.3 inches, and 26.1 BMI, respectively. The comparable measurements for women were 140.7 pounds, 64.8 inches, and 23.5 BMI versus their self-reports of 140.5 pounds, 65.4 inches, and 23.2 BMI. No statistically significant differences were found between self-reported and measured weight or height.

Anthropometric Characteristics of the Military Population

Table 2 shows summary statistics (based on weighted sample) for anthropometric characteristics of sample women by demographic variables. Pregnant women were excluded from all analyses so as not to distort the summary statistics presented in this report. The average height of Navy and Marine Corps women between the ages of 18 to 54 was 64.8 inches. The average weight of these women was 141.5 pounds. Increases in weight were noted with age, Wald $F(4, 1262)^d = 3.37$, $p = .02$, and female officers weighed, on average, at least 5 pounds less than enlisted personnel, $F(3, 1262) = 7.57$, $p < .001$.

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[d] Degrees of freedom for all subgroups analyzed for body measurements were based on a single stage design and calculated as the number of subjects minus the number of strata (1,292 – 30) similar to *e* for a multistage design reported by Shah, B.V., Barnwell, B.G., & Bieler, G.S., 1996, p. 4-3. All F tests reported used the Wald statistic.

Subscapular and triceps skinfolds were approximately equal among active-duty women, 17.3 mm and 18.0 mm, respectively. Subscapular skinfolds were larger among women of other races, $t_{1262} = 4.64$, $p < .001$, whereas triceps measurements were approximately equal for the two groups. Both skinfold measures showed increases in thickness among 45-54 year-old women. Similar to the weight differentials between officers and enlisted personnel, the smallest subscapular skinfold measurements were noted for officers, $F(3, 1262) = 16.60$, $p < .001$ and likewise for triceps measurements, $F(3, 1262) = 4.87$, $p < .01$.

The circumference measurements taken in this study included neck, abdomen, and hip. These girth measurements, when combined with height, produced an estimate of body fat. The average values for women's neck size, abdomen, and hip are 32.6 cm, 73.5 cm, and 100.0 cm, respectively. Although abdomen and hip girths appeared to increase slightly with age, only neck circumference reached statistical significance $F(4, 1262) = 2.66$, $p = .05$. Based on circumference measurements, officers appeared to be leaner than enlisted personnel (neck: $F[3, 1262] = 7.39$, $p < .001$; abdomen: $F[3, 1262] = 18.86$, $p < .001$; and hip: $F[3, 1262] = 11.92$, $p < .001$).

Height and weight data, taken in ratio, furnished an estimate of body fat. Military women had an average BMI of 23.6. While this was well below the 1987 NHANES cutoff for BMI of 27.3, which stipulates an overweight condition, 15.3% of military women in the study exceeded this cutoff (see Overweight % column in Table 2). The first %BF shown in Table 2 is the unadjusted value based on the generalized equations of Hodgdon and Beckett.[16-17] The second %BF is age-adjusted. The mean values for the unadjusted %BF and adjusted %BF among women in our sample were 28.8 and 29.6, respectively. Although the mean value of BMI is fairly stable across age groups at around 23, there was a small increase in %BF with age of about

2 units and a larger increase in the adjusted %BF of nearly 5 units. However, only the adjusted %BF was statistically significant, $F(4, 1262) = 9.06$, $p < .001$. More pronounced differences were observed for the prevalence of an overweight condition in women between the age groups of 35-44 and 45-54, amounting to a two- to three-fold increase in the later years. For both measures of %BF, officers showed approximately 4%BF less than E7s to E9s, $F(3, 1262) = 20.0$, $p < .001$. Similarly, officers were half as likely as enlisted personnel to be overweight.

Table 3 reports the same anthropometric data for men as for women, omitting only hip girth and age-adjusted %BF which was available for women only. The average height of military men ages 18 to 54 was 69.5 inches. Height did not vary by subgroups based on sample demographics. Military men of all ages weighed 176.4 pounds, on average. There was a weight differential of roughly 12 pounds between the youngest and oldest groups in our sample, though it was not statistically significant. The lowest ranked enlisted personnel (E1 to E6) weighed considerably less than higher ranked enlisted personnel or officers $F(3,1262) = 4.03$, $p = .02$. This difference may be partially attributed to their younger age.

The average subscapular skinfold among military men was 16.3, nearly twice as high as their mean triceps skinfold measurement of 9.4. Although both skinfold measures increased with age (subscapular: $F[4, 1262] = 4.92$, $p < .01$; triceps: $F[4, 1262] = 3.38$, $p = .02$), changes in subscapular skinfold dimensions were more pronounced when comparing the youngest and oldest groups represented in the sample. Skinfold measurements were not significantly different based upon rank.

Circumference measurements for men's neck size and abdomen were 39.2 cm and 89.8 cm, respectively. Mean abdomen girths showed substantial increases with age, from 87.2 cm for

military men between the ages of 18 to 24 years to 98.2 cm for the 45- to 54-year-old group, $F(4, 1262) = 11.99$, $p < .001$. E1s to E6s presented a leaner appearance than higher ranked enlisted personnel or officers, $F(3, 1262) = 8.33$, $p < .001$.

Military men had a mean BMI of 25.7. Using the 1987 NHANES definition of overweight for men, which was a BMI value of 27.8, nearly one fourth of our sample of Navy and Marine Corps men was overweight. The mean value for %BF among men in our sample was 19.1. Body fat comparisons between men and women showed the normal 8 to 10 percentage point difference between the sexes.[7] Both BMI and %BF increased with age (BMI: $F[4, 1262] = 5.13$, $p < .01$; %BF: $F[4, 1262] = 18.48$, $p < .001$). Average BMI varied between 25.4 and 27.6 for the youngest and oldest groups of military men. %BF was more wide ranging than BMI for the same age comparison, from 17.5% to 24.7%. Like each of the body composition measures previously discussed, E1s to E6s presented the leanest profile. Detailed tables presenting summary statistics and selected percentiles for BMI and %BF by sex, age, race, paygrade and service are available from the author.

Comparison of Anthropometric Characteristics of Navy and Marine Corps Personnel

Table 4 shows selected anthropometric characteristics for women of the Navy and the Marine Corps. As a result of the stricter weight standard applied in the Marine Corps, female Marines weighed nearly 10 pounds less than Navy women, $t = 5.0$, $p < .001$. A leaner profile among Marine Corps women was also demonstrated by smaller skinfold measurements, lower BMI values, and less body fat. In addition, three times fewer overweight women were serving in the Marine Corps than in the Navy (6.0% vs. 19.0%). Although women of the Marine Corps were leaner than Navy women were, because their weight-for-height standard is more stringent

than the Navy's, a greater proportion exceeded their respective branch's weight-for-height standards (36.0% vs. 19.0%). The differences in anthropometric characteristics, which were found between Navy and Marine Corps women, were generally observed in the White and other race categories.

In practice, the Navy uses the weight-for-height standard as a prescreen. Only if a sailor exceeds the prescreen will circumference measurements be taken to estimate %BF. The %BF data were based on the entire population, rather than the subset failing the height-weight prescreen. Between the ages of 18 and 34, the proportions of Navy women who were overweight and who exceeded their branch's weight-for-height standards remained stable at about 1 in 5. A slight drop in these proportions occurred at age 35, followed by a doubling of the fraction of Navy women who exceeded either weight standard at age 45. These later figures are not tabled due to their lower sample sizes and more unstable estimates. The fraction of Navy women who exceeded the body fat standard remained constant at about 45% for each age interval with the exception of 45 to 54 years, where fully half appeared not in compliance. The group that most often exceeded the weight-for-height standard among female Marines was 25 to 34 years of age. Comparing personnel of the same rank, female E1s to E6s of the Marines were consistently leaner than Navy women of the same rank.

Similar to the branch of service differences noted in women's physique, Navy men were slightly heavier than their Marine Corps counterparts and had greater skinfold thickness and %BF (see Table 5). These differences were more pronounced for white men and for all age groups except years 18 to 24. Skinfold thickness and %BF were consistently lower for Marine Corps E1s to E6s than for similarly ranked male sailors. Higher ranked enlisted personnel and officers of the Marine Corps also presented smaller triceps skinfolds than Navy men.

Navy men 18 to 24 years of age were the leanest based on consideration of any of the three standards. A sharp rise in the fraction of male sailors ages 25 to 34 who exceeded the weight-based (overweight or weight-for-height) and body fat standards was followed by a subsequent drop in the weight-based measures at age 35. Among Navy men 45-54 years of age, a dramatic rise occurred in the proportion who exceeded the Navy's body fat criterion to nearly 80%, though it was not accompanied by an increase in the numbers exceeding either of the weight-based standards. Again, these figures are based on a smaller sample size. The prevalence of overweight male Marines and the fraction who exceeded branch weight-for-height standards was roughly the same for each age group. Up until age 34, these rates were 20% or less. By age 35, the fraction of the population exceeding either standard rose to approximately 36%.

Overweight Navy personnel of all races were clustered in the enlisted ranks of E1 to E6, whereas among Marines, the greatest proportion of those exceeding standards was found in the enlisted rank of E7-E9 (see Tables 4 & 5). Officers generally showed the lowest proportion of overweight personnel among their ranks, with the exception of male Marines. Consistent with %BF data presented earlier, female and male officers of the Navy more often met weight-for-height standards than did enlisted personnel. While this is also true for Marine Corps women, male officers of this service had greater %BF than did enlisted personnel of rank E1 to E6.

DISCUSSION

This study provided detailed distributions of several body composition measures on which to assess different cutoffs for various segments of the military population. The study's main strengths were that body measurement participants were chosen from a population-based sample, a large number of women were represented in this sample, and the study included

physical measurements on many anthropometric dimensions, not just self-reported height and weight. Although the low response rate for the questionnaire survey may have impacted who was chosen for the physical measurement study, based on the demographic, height, and weight similarities between population and sample/subsample distributions, the sample appeared to be generally representative. Perhaps the most significant shortcoming of this research was that "other" races could not be broken out into black, Hispanic, Asian, and other. This was particularly salient since African-Americans constitute a large percentage of active-duty Navy enlisted personnel (nearly 20%), while Hispanics represent a growing segment of the population.

Using the 1987 NHANES criterion for overweight, which are based on BMI, approximately 15% of military women and 23% of military men had exceeded the cutpoint levels of BMI. The prevalence of overweight was considerably lower among Marine Corps women in comparison with Navy women and slightly less for Marine Corps men when compared with their Navy counterparts. Navy women tended to meet weight-based standards more often than Navy men did. Fewer Marine Corps women than men were overweight but more exceeded their weight-for-height standards. Nearly 45% of Navy men and women were assessed as being above maximum allowable %BF. Whereas weight significantly increased with age among women but not BMI or %BF, the opposite trend was observed for men in which BMI and %BF significantly increased with age but not weight alone. Skinfold thickness tended to be less among E1 – E6 and officers relative to E7-E9s, particularly among Marines.

The latest National Health and Nutrition Exam Survey reported that 35% of adults age 20 and older are overweight.[24] The prevalence of overweight among Americans has increased 5% between 1987 and 1993.[25] This fattening of Americans may help to explain the significant increase in the proportion of Navy personnel who exceeded the maximum allowable %BF from

previously reported data. The 1989 Conway et al. study showed only 9.4% of men and 9.7% of women exceeded body fat standards.[26-27] Sampling and data collection procedures between the present and the previous study were also very different. For example, Conway et al. [26-27] collected %BF data from PRT scores, and Navy PRT measurements were recorded to the nearest half inch, specifying that neck be rounded up and waist rounded down, giving the advantage to the sailor. Measurements taken in the present study used the actual decimal places and did not round. Also in the earlier study, height/weight tables were rounded to nearest whole numbers, and there were differences in the computation of the 22% and 30% cutoffs (i.e., 29.9% counted as within standards versus exceeding standards). Further, there may be differences between measurements taken by the researchers, specifically trained to achieve a high level of interrater reliability, and PRT measurements taken in the field (e.g., is the tape being pulled a little tighter to help people pass their test?). BMI figures may thus be more consistent and comparable than the %BF as they are based on standard height and weight measures whereas the %BF measure is somewhat more vulnerable to measurement error. More than likely, the observed increase in %BF is a combination of all these things. Although this study incorporated methods to ensure a representative sampling frame and appropriate weighting scheme, the number of primary sampling units was small and some sampling bias may occur, as with all such surveys, if either more overweight personnel responded to the survey or (biased in the opposite direction) more lean people consented to have their measurements taken. Unfortunately, there is no adequate way of estimating such a bias. However, some preliminary results of ongoing studies appear to help corroborate the present findings (personal communication, K. Kujawa, 1997). A final caveat cautions against placing undue emphasis on findings in the older age groups. Some cells,

particularly those of women and Marines, were quite small and may be less reliable than those with larger numbers.

Much of this report addresses the subgroups of military personnel defined by gender, age, race, paygrade, and branch of service who fail the NHANES standard for overweight and the military's standards for weight and %BF. Body composition profiles of Navy and Marine Corps personnel suggest that the services could find the costs of weight reduction treatment to be prohibitive should they decide to strictly adhere to their body fat and weight-for-height standards.[29] Results for the Navy's weight-for-height prescreen indicate that 1 in 5 Navy women would require treatment for an overweight condition. More Navy men, 1 in 4, would require weight reduction. Treating this fraction of the Navy population requires substantial resources, yet might be deemed manageable, especially in light of the relative ease with which military personnel can potentially increase their activity or exercise. However, providing either inpatient or outpatient treatment to the nearly 45% of men and women who exceeded the Navy's %BF limits seems impractical. The implications for treatment based on the outcomes of this study with regard to the NHANES standard are similar to the Navy's weight-based prescreen. Given the proportion of female Marines not meeting their weight-for-height standards despite their acceptable BMIs suggests that the Marine Corps' weight-for-height standard for women may be overly stringent. Treating male Marines under the age of 35 who exceed either of the weight-based standards may be possible, but it would be impractical for the large numbers between the ages of 35 to 44 years who are out of standard. Previous studies of obese Navy personnel suggest treatment costs for the most obese alone are high[28] and absolute losses of %BF for participants in the Navy's obesity treatment program are small (3.7% for males and 4.5% for females "despite the need of the average participant to lose almost twice these amounts to meet the Navy's

acceptable body fat level").[29] Given not only such cost and effectiveness issues but evidence that weight loss may lead to weight cycling and adverse health effects,[30] it may be suggested that fitness and nutritional maintenance programs designed to prevent overweight may be more efficient than weight reduction or obesity treatment programs and should be given greater focus within the Navy.

One of the unique findings in this study was the incongruence between NHANES overweight standards (BMI), height-weight standards, and %BF standards across sex and services. For example, a 10 lb. difference between female Sailors and Marines produced a 3-fold difference in % overweight by BMI in favor of the Marines, yet by their own height-weight standards, these same Marines were twice as likely to exceed standards. Research on both the national BMI standards[31-33] and military %BF[34-37] equations has continued toward better validation and prediction related to health and fitness outcomes, and both services have undergone changes in their standards since the onset of this study. Subsequent papers will address the impact of revised Navy and Marine Corps standards, examine health and fitness correlates of both elevated BMI and excessive %BF, and compare military with civilian distributions.

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Table 1. Survey response data and participation rates for body measurement study, U.S. Navy and Marine Corps, 1995

Group Session Site		USMC	Navy	Total
Questionnaire Study				
1.	Number of eligible persons	1,664	2,544	4,208
2.	Number of respondents	726	1,680	2,406
3.	Response rate among eligibles (%) = Item 2/Item 1 × 100	43.6	66.0	57.2
Body Measurement Study				
4.	Number of eligible persons selected	450	959	1,409
5.	Number of participants	438	854	1,292
6.	Cooperation rate (%) = Item 5/Item 4 × 100	97.3	89.1	91.7
7.	Participation rate among selected eligibles (%) = (Item 3 X Item 6) /100	42.4	58.8	52.5

Table 2. Anthropometric characteristics by demographic variables of women, U.S. Navy and Marine Corps, 1995

Anthropometric characteristic (mean and standard error) Demographic category	N	Height, in	Weight, lbs	Skinfold, mm		Circumference, cm			BMI[1]	%BF[2]	%BF adj[3]	Over-Weight[4] (%)
				Subscapular	Triceps	Neck	Abdomen	Hip				
All women	621	64.8 (.10)	141.5 (.97)	17.3 (.29)	18.0 (.25)	32.6 (.07)	73.5 (.30)	100.0 (.31)	23.6 (.13)	28.8 (.23)	29.6 (.21)	15.3
Race												
White	419	65.1 (.12)♦♦♦	141.8 (1.19)	16.4 (.36)♦♦♦	18.2 (.32)	32.5 (.09)	73.3 (.37)	100.0 (.39)	23.5 (.16)	28.6 (.29)	29.4 (.26)	14.5
Other	202	64.3 (.18)	140.8 (1.67)	19.3 (.50)	17.3 (.39)	32.7 (.12)	74.0 (.54)	99.8 (.51)	24.0 (.22)	29.4 (.41)	30.1 (.36)	17.0
Age												
18 - 24	238	64.5 (.16)'	138.6 (1.53)'	17.0 (.46)'	17.3 (.40)'''	32.4 (.11)'	72.8 (.49)	99.1 (.47)	23.4 (.21)	28.3 (.38)	28.6 (.34)'''	15.6**
25 - 34	233	65.1 (.17)	144.9 (1.61)	17.7 (.51)	18.4 (.44)	32.8 (.12)	74.2 (.51)	100.8 (.52)	24.0 (.20)	29.3 (.38)	30.3 (.34)	16.0
35 - 44	131	65.1 (.20)	140.6 (1.97)	16.9 (.58)	18.3 (.51)	32.3 (.13)	73.6 (.56)	100.1 (.62)	23.3 (.28)	28.8 (.47)	30.7 (.42)	11.9
45 - 54	19	65.5 (.55)	150.0 (5.84)	20.2 (1.04)	22.6 (1.06)	33.1 (.38)	75.9 (1.56)	102.1 (2.26)	24.3 (.69)	30.3 (1.34)	33.2 (1.20)	37.5
Paygrade[5]												
E1 - E6	431	64.7 (.12)'''	141.6 (1.15)'''	17.5 (.35)'''	18.0 (.30)''	32.6 (.08)'''	73.6 (.36)'''	100.0 (.37)'''	23.8 (.15)'''	29.0 (.28)'''	29.6 (.25)'''	16.5***
E7 - E9	52	65.4 (.25)	148.5 (2.75)	19.2 (.72)	19.4 (.67)	33.0 (.24)	76.4 (.86)	102.7 (.89)	24.3 (.36)	31.0 (.65)	32.7 (.60)	17.0
Officer	135	65.5 (.19)	137.4 (1.31)	15.0 (.43)	17.1 (.38)	32.1 (.12)	71.2 (.41)	98.3 (.42)	22.5 (.17)	26.7 (.33)	28.4 (.32)	7.0

[1]Weight (kg)/Height (meter)^2.
[2]Percent body fat formula developed by Hodgdon and Beckett (1984b, 1984c) using circumferences and height.
[3]Percent body fat formula developed by Tran & Weltman (1989) using circumferences, height, and age.
[4]Overweight was defined in terms of BMI greater than or equal to 27.3 for women and 27.8 for men and reported as a percentage.
[5]Unknown for 3 persons.
Significance: Wald F-statistic ' $p \leq .05$ '' $p \leq .01$ ''' $p \leq .001$.
Chi-square: * $p \leq .05$ ** $p \leq .01$ *** $p \leq .001$.
t-test: ♦ $p \leq .05$ ♦♦ $p \leq .01$ ♦♦♦ $p \leq .001$.

Table 3. Anthropometric characteristics by demographic variables, men, U.S. Navy and Marine Corps, 1995

Anthropometric characteristic (mean and standard error) Demographic category	N	Height, in	Weight, lbs	Skinfold, mm		Circumference, cm		BMI	%BF	Over-Weight (%)
				Subscapular	Triceps	Neck	Abdomen			
All men	626	69.5 (.21)	176.4 (1.80)	16.3 (.51)	9.4 (.21)	39.2 (.17)	89.8 (.68)	25.7 (.23)	19.1 (.43)	23.2
Race										
White	349	69.7 (.26)	176.5 (2.24)	16.1 (.63)	9.4 (.25)	39.2 (.21)	90.1 (.87)	25.6 (.29)	19.2 (.54)	23.0
Other	277	69.0 (.32)	176.0 (2.77)	17.1 (.77)	9.5 (.34)	39.0 (.23)	88.8 (.93)	26.0 (.26)	18.8 (.56)	23.7
Age[1]										
18 - 24	102	69.1 (.31)	172.3 (3.25)	15.1 (.92) [II]	8.8 (.34) [I]	39.0 (.32)	87.2 (1.24) [III]	25.4 (.39) [II]	17.5 (.75) [III]	17.5***
25 - 34	225	70.2 (.46)	178.9 (2.95)	16.9 (.72)	10.4 (.38)	39.2 (.21)	91.2 (1.01)	25.5 (.41)	19.8 (.68)	23.4
35 - 44	269	69.5 (.24)	180.9 (2.03)	17.8 (.69)	9.6 (.37)	39.3 (.20)	92.5 (.82)	26.4 (.33)	21.1 (.53)	31.9
45 - 54	29	68.7 (.66)	184.9 (4.46)	20.8 (1.20)	10.3 (.77)	40.4 (.49)	98.2 (1.38)	27.6 (.49)	24.7 (.65)	51.8
Paygrade										
E1 - E6	306	69.4 (.26)	174.7 (2.25) [I]	16.1 (.63)	9.3 (.25)	39.1 (.21)	88.9 (.86) [III]	25.5 (.28) [I]	18.6 (.53) [III]	21.9***
E7 - E9	189	69.5 (.22)	182.2 (1.96)	17.3 (.45)	10.0 (.30)	39.4 (.16)	93.1 (.63)	26.5 (.27)	21.4 (.37)	30.2
Officer	131	70.1 (.29)	182.8 (2.51)	16.8 (.65)	9.7 (.39)	39.7 (.22)	92.7 (.91)	26.1 (.32)	20.6 (.56)	25.5

Significance: Wald F-statistic [I] $p \leq .05$ [II] $p \leq .01$ [III] $p \leq .001$.
Chi square * $p \leq .05$ ** $p \leq .01$ *** $p \leq .001$.
[1]Unknown for 1 person.

Table 4. Comparison of women on selected anthropometric characteristics by race, age, and paygrade, U.S. Navy and Marine Corps, 1995

Demographic category	N Navy	N Marines	Height, in Navy	Height, in Marines	Weight,lbs Navy	Weight,lbs Marines	Skinfold, mm Subscapular Navy	Skinfold, mm Subscapular Marines	Skinfold, mm Triceps Navy	Skinfold, mm Triceps Marines	BMI Navy	BMI Marines	%BF Navy	%BF Marines	Overweight (%) Navy	Overweight (%) Marines	Exceed ht/wt Standard (%)[1] Navy	Exceed ht/wt Standard (%)[1] Marines
			Anthropometric characteristic (mean and standard error)															
All military women	401	220	64.9 (.12)	64.7 (.17)	144.7 (1.3)	135.4*** (1.3)	18.5 (.39)	15.1*** (.39)	19.5 (.34)	15.1*** (.32)	24.1 (.17)	22.8*** (.17)	29.3 (.32)	28.0** (.32)	19.0	6.0***	19.0	36.0
Race																		
White	272	147	65.3 (.15)	64.7* (.21)	145.1 (1.59)	134.9*** (1.54)	17.5 (.49)	14.1*** (.41)	19.8 (.44)	15.0*** (.39)	23.9 (.21)	22.6*** (.20)	29.0 (.38)	27.6* (.39)	17.9	5.2***	19.0	32.1
Other	129	73	64.0 (.23)	64.7 (.30)	143.7 (2.24)	136.3* (2.46)	20.8 (.64)	16.9*** (.80)	18.9 (.52)	15.3*** (.57)	24.6 (.31)	23.0*** (.32)	29.8 (.55)	28.6 (.59)	21.6	7.3***	18.9	42.9
Age																		
18 - 24	129	109	64.3 (.20)	64.7 (.25)	142.1 (2.23)	133.9** (1.90)	18.7 (.69)	14.7*** (.55)	19.3 (.59)	14.5*** (.45)	24.1 (.31)	22.5*** (.25)	29.0 (.56)	27.3* (.48)	22.2	4.8***	20.5	30.8
25 - 34	157	76	65.4 (.21)	64.3** (.28)	148.7 (2.08)	136.4*** (2.17)	18.7 (.65)	15.5*** (.73)	19.8 (.57)	15.3*** (.52)	24.4 (.26)	23.1*** (.26)	29.6 (.50)	28.6 (.49)	18.5	7.6*	20.8	43.3
35 - 44	98	33	65.0 (.23)	65.4 (.36)	141.2 (2.33)	138.9 (3.53)	17.3 (.73)	15.8 (.82)	18.8 (.60)	16.9 (.86)	23.5 (.33)	22.8 (.46)	28.8 (.56)	29.1 (.84)	12.3	7.0	10.7	38.0
45 - 54[2]																		
Paygrade																		
E1 - E6	263	168	64.8 (.15)	64.5 (.20)	145.6 (1.58)	134.4*** (1.50)	18.9 (.48)	15.1*** (.45)	19.8 (.42)	14.8*** (.36)	24.3 (.21)	22.7*** (.20)	29.6 (.38)	27.8*** (.37)	21.2	6.1***	21.1	35.4
E7 - E9	37	15	64.8 (.33)	66.3** (.39)	147.3 (3.49)	150.5 (4.48)	19.6 (.93)	18.6 (1.11)	19.6 (.88)	19.1 (1.03)	24.5 (.49)	24.0 (.53)	30.5 (.92)	32.0 (.80)	16.2	13.3	17.5	60.0
Officer	100	35	65.5 (.21)	65.3 (.40)	138.4 (1.50)	134.5 (2.62)	15.8 (.55)	12.8*** (.54)	17.8 (.46)	15.1*** (.68)	22.6 (.21)	22.2 (.27)	26.7 (.41)	26.6 (.54)	7.2	0.0***	7.3	25.7

[1]Because the weight-for-height standards are different for the Navy and Marine Corps, proportional differences were not tested.
[2]Due to few cases for female Marines, ages 45-54 (n = 7), results are not shown.
Significance: t-test, *= .05, **= .01, ***= .001.

Table 5. Comparison of men on selected anthropometric characteristics by race, age, and paygrade, U.S. Navy and Marine Corps, 1995

Demographic category	N Navy	N Marines	Height, in Navy	Height, in Marines	Weight, lbs Navy	Weight, lbs Marines	Skinfold, mm: Subscapular Navy	Subscapular Marines	Skinfold, mm: Triceps Navy	Triceps Marines	BMI Navy	BMI Marines	%BF Navy	%BF Marines	Overweight (%) Navy	Overweight (%) Marines	Exceed ht/wt Standard (%)[1] Navy	Exceed ht/wt Standard (%)[1] Marines
All military men	438	188	69.7 (.15)	69.4 (.29)	180.6 (1.41)	174.5* (2.51)	18.0 (.34)	15.6** (.71)	10.9 (.24)	8.8*** (.28)	26.2 (.18)	25.5 (.32)	20.8 (.30)	18.4*** (.60)	30.0	19.9*	26.3	21.8
Race																		
White	249	100 (.17)	70.2 (.37)	69.4* (1.68)	183.5 (3.15)	173.3** (.42)	17.7 (.89)	15.3* (.30)	11.1 (.34)	8.6*** (.22)	26.2 (.41)	25.3 (.36)	21.2 (.77)	18.3***	31.6	18.7*	27.8	19.3
Other	189	88	68.0 (.26)	69.4** (.43)	171.6 (2.55)	177.7 (3.74)	18.8 (.55)	16.5 (1.06)	10.3 (.33)	9.2† (.46)	26.0 (.30)	25.9 (.35)	19.5 (.46)	18.6 (.76)	25.1	22.9	21.7	28.7
Age																		
18 - 24	50	52	69.3 (.46)	69.1 (.34)	171.9 (3.56)	172.4 (3.55)	15.1 (.82)	15.1 (1.01)	10.0 (.63)	8.7 (.37)	25.3 (.48)	25.4 (.43)	17.6 (.87)	17.5 (.82)	21.4	17.2	17.3	19.6
25 - 34	177	48	70.1 (.23)	70.4 (.90)	183.8 (2.25)	173.8 (5.49)	18.7 (.53)	15.0* (1.26)	11.3 (.38)	9.3** (.63)	26.3 (.28)	24.7* (.73)	20.9 (.46)	18.7 (1.30)	35.0	10.4***	31.6	11.7
35 - 44	187	82	69.5 (.21)	69.4 (.42)	180.1 (2.28)	181.5 (3.28)	18.0 (.56)	17.6 (1.20)	10.8 (.37)	8.6*** (.54)†	26.2 (.30)	26.5 (.57)	21.5 (.44)	20.7 (.91)	27.3	35.3	24.1	36.2
45 - 54[2]																		
Paygrade																		
E1 - E6	239	67 (.18)	69.5 (.34)	69.4 (1.85)	179.6 (2.95)	173.0 (.45)	18.1 (.83)	15.5** (.29)	10.8 (.32)	8.8*** (.24)	26.1 (.37)	25.3 (.39)	20.4 (.70)	18.0**	32.7	18.3*	28.8	20.1
E7 - E9	129	60	69.4 (.26)	69.5 (.39)	180.9 (2.64)	183.9 (2.92)	17.9 (.58)	16.5 (.71)	11.0 (.45)	8.6*** (.37)	26.3 (.33)	26.8 (.45)	21.9 (.46)	20.7 (.62)	26.9	31.5	23.4	33.5
Officer	70	61	70.7 (.45)	69.8 (.37)	184.3 (3.36)	181.7 (3.56)	17.6 (.93)	16.3 (.89)	11.5 (.70)	8.5*** (.43)	26.0 (.47)	26.3 (.43)	21.3 (.78)	20.2 (.77)	22.2	26.2	19.3	29.3

[1]Because the weight-for-height standards are different for the Navy and Marine Corps, proportional differences were not tested.
[2]Due to few cases for male Marines ages 45-54, results are not shown.
Significance: t-test, *p ≤ .05, **p ≤ .01, ***p ≤ .001.

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DEMOGRAPHIC DIFFERENCES IN BODY COMPOSITION OF NAVY AND MARINE CORPS PERSONNEL: FINDINGS FROM THE PERCEPTION OF WELLNESS AND READINESS ASSESSMENT

Wendy F. Graham, Ph.D., Laurel L. Hourani, Ph.D, M.P.H., Diane Sorenson, M.P.H., and Huixing Yuan, Ph.D.

Department of Health Sciences and Epidemiology, Naval Health Research Center, P. O. Box 85122, San Diego, CA

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With the recent increase in women's representation in the military, baseline physical measurement data is needed to help set appropriate accession and retention standards and to design useful prevention and intervention programs in the areas of physical fitness and health. This study incorporated several body composition indices to obtain anthropometric data for a representative sample of 1292 active-duty Navy and Marine Corps women and men. It also assessed the extent to which personnel met weight-for-height and body fat standards. The prevalence of overweight was considerably lower among Marine Corps women as compared with Navy women and slightly less for Marine Corps men compared with their Navy counterparts. Between one fifth and one third of military personnel exceeded Navy/ Marine Corps weight-for- height standards. Navy women tended to meet weight standards more often than Navy men. Fewer Marine Corps women than men were overweight but more exceeded their weight-for-height standards.

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